Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

S4C
B5

# Suitability of Various Soils for Tung Production

Circular No. 840
U. S. DEPARTMENT OF AGRICULTURE

*Circular* No. 840

July 1950 • Washington, D. C.

UNITED STATES DEPARTMENT OF AGRICULTURE

# Suitability of Various Soils for Tung Production

By MATTHEW DROSDOFF, *soil technologist, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration*

## CONTENTS


| | Page |
|---|---|
| Introduction | 1 |
| Soil classification | 3 |
| Soils of peninsular Florida | 4 |
| General considerations | 4 |
| Brief descriptions | 5 |
| Soil-type experiments | 6 |
| Physical and chemical properties | 6 |
| Soil management | 9 |
| Fertilization | 10 |
| Soils of northern and western Florida, southern Georgia, and southern Alabama | 11 |
| General considerations | 11 |
| Brief descriptions | 11 |
| Physical and chemical properties | 12 |
| Soil management | 14 |
| Soils of northern and western Florida, southern Georgia, and southern Alabama—Continued | |
| Fertilization | 14 |
| Soils of southern Mississippi and southeastern Louisiana | 15 |
| General considerations | 15 |
| Brief descriptions | 16 |
| Soil-type experiments | 17 |
| Physical and chemical properties | 18 |
| Soil management | 20 |
| Fertilization | 20 |
| Soils of western Louisiana and eastern Texas | 21 |
| Comparative value of different soils for tung production | 21 |
| Literature cited | 22 |


## INTRODUCTION

Since the first large commercial tung (*Aleurites fordii* Hemsl.) orchard was planted in Florida in 1924, there has been a gradual expansion in tung acreage in this country. At present it is estimated that there are about 166,000 acres of trees, all but a small portion of them in a narrow belt 50 to 100 miles wide extending from eastern Texas along the Gulf of Mexico to the Atlantic Ocean, including about the northern third of Florida and the southern quarter of Georgia. Figure 1 shows the distribution of tung orchards in this belt, and table 1 gives the approximate total acreages by States and counties or parishes. Climate is the main factor that confines tung production to this region.



868901—50——1

Large acreages with soil well suited to growing tung trees can be found throughout the tung belt. Good drainage is probably the most important requisite. Many soils, even though they are suited to other crops, are not sufficiently well drained for growing tung trees. Either the permanent water table is too high or else the drainage is hindered by a hardpan or heavy clay layer. That tung trees will not grow well under poor drainage was well illustrated at an early date by the failure of the first commercial orchard planted in the United States. This orchard, located near Gainesville, Fla., was planted in 1924 on a poorly drained flatwoods soil (Leon fine sand). Most of the trees eventually died, and the orchard was finally abandoned. This was a discouraging beginning for the infant industry, but out of this and similar experiences came the recognition of the importance of suitability of the soil in tung production.

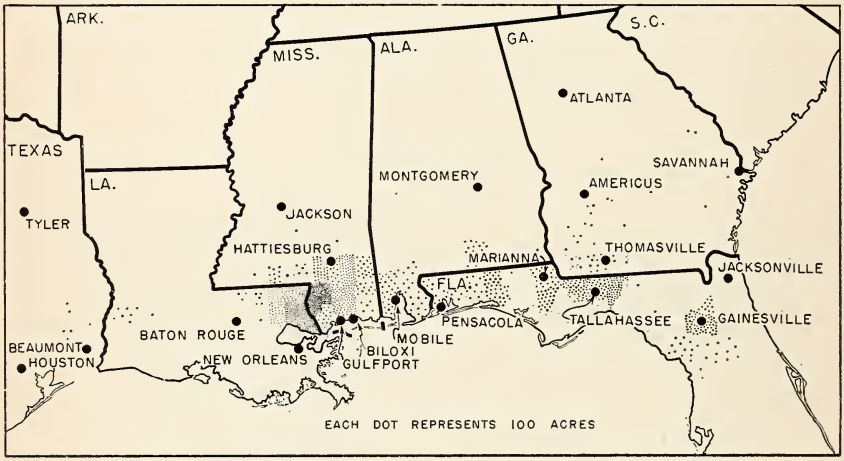


FIGURE 1.—Distribution of tung acreage in southeastern United States in 1948. The data for this figure were compiled from the best available sources. The 1945 Census of Agriculture was used as a basis, and acreages were modified in accordance with the most recent information available on new plantings and abandoned acreage.

Tung, like most other tree crops, does best on soils that have, in addition to good drainage and aeration, a relatively high moisture- and nutrient-holding capacity. Soils of the river bottoms or terraces or in low-lying areas of the upland are not recommended because of the frost hazard. Steeply sloping land though usually well drained should be avoided because it is easily eroded and difficult to cultivate. The soils should be easily penetrated by plant roots and have an adequate nutrient level. Practically all the soils in the tung belt are relatively low in natural fertility and require the addition of fertilizers and soil amendments to make the orchards produce satisfactorily. Tung trees do well on soils that are moderately acid (pH 5.5 to 6.5). Soils of the tung-growing region, eastern Texas to Florida, universally meet this requirement. Experience with tung in soils that are neutral or alkaline (pH 7.0 to 7.5) is very limited, but such soils are probably less well suited than slightly to moderately acid ones.

TABLE 1.—*Approximate acreages in tung in Southeastern United States by States and counties or parishes, 1948*

[Compiled as indicated in legend for figure 1]

| State and county or parish | Approximate acreage |
|---|---|
| Georgia: | *Acres* |
| Baker | 300 |
| Brooks | 100 |
| Bryan | 100 |
| Calhoun | 100 |
| Crisp | 200 |
| Decatur | 400 |
| Dougherty | 200 |
| Grady | 800 |
| Jenkins | 200 |
| Lee | 300 |
| Miller | 100 |
| Mitchell | 100 |
| Peach | 100 |
| Telfair | 100 |
| Thomas | 400 |
| Tift | 100 |
| Wayne | 100 |
| Total | 3, 700 |
| Florida: | |
| Alachua | 6, 000 |
| Bradford | 1, 200 |
| Calhoun | 3, 000 |
| Citrus | 200 |
| Escambia | 800 |
| Gadsden | 4, 000 |
| Holmes | 100 |
| Jackson | 1, 800 |
| Jefferson | 6, 000 |
| Lafayette | 100 |
| Leon | 3, 500 |
| Levy | 1, 300 |
| Madison | 100 |
| Marion | 1, 000 |
| Okaloosa | 1, 000 |
| Santa Rosa | 600 |
| Walton | 4, 000 |
| Total | 34, 700 |
| Alabama: | |
| Baldwin | 2, 000 |
| Barbour | 100 |
| Covington | 1, 300 |
| Alabama—Continued | |
| Houston | 100 |
| Mobile | 3, 000 |
| Total | 6, 500 |
| Mississippi: | |
| Amite | 100 |
| Forrest | 1, 300 |
| George | 1, 200 |
| Greene | 2, 000 |
| Hancock | 1, 500 |
| Harrison | 4, 000 |
| Jackson | 500 |
| Jones | 100 |
| Lamar | 4, 000 |
| Marion | 500 |
| Newton | 100 |
| Pearl River | 60, 000 |
| Perry | 8, 000 |
| Pike | 1, 100 |
| Simpson | 100 |
| Stone | 6, 000 |
| Walthall | 100 |
| Total | 90, 600 |
| Louisiana: | |
| Allen | 100 |
| Beauregard | 700 |
| East Feliciana | 300 |
| Livingston | 100 |
| St. Helena | 500 |
| St. Tammany | 16, 000 |
| Tangipahoa | 7, 000 |
| Washington | 5, 000 |
| Total | 29, 700 |
| Texas: | |
| Hardin | 300 |
| Jasper | 100 |
| Tyler | 200 |
| Total | 600 |
| Grand total | 165, 800 |

## SOIL CLASSIFICATION

A soil series is defined as a group of soils having layers, or horizons, with similar characteristics, not taking into account the texture of the surface soil. These characteristics include the structure, color, consistence, texture, thickness and arrangement of the soil layers,

organic-matter content, and degree of acidity. Soils within each series develop from similar parent material under a relatively narrow range of climate and relief. A soil series is given a name taken from a place such as a town, a river, or other landmark near where the soil was first officially recognized. For example, the Gainesville series was first described from studies made on soils near the city of Gainesville, Fla.

The name of a soil type is the same as that of the soil series except that the texture of the surface soil is included. Thus, there may be one or more soil types within each series. For example, Gainesville loamy fine sand and Gainesville fine sandy loam are two soil types included in the Gainesville series. The texture is determined by the relative amounts of sand, silt, and clay present. For example, a sand contains 85 percent or more of sand; the silt plus 1½ times the clay does not exceed 15 percent. A sandy loam contains more than 15 percent silt and clay and either less than 20 percent clay and 52 up to 80 percent sand or less than 10 percent clay, less than 52 percent sand, and less than 50 percent silt.[1] The reason that emphasis is given to the surface soil is that most crop plants have the greater part of their roots in the surface soil, which is directly involved in tillage and fertilization.

The tung belt (fig. 1) can be divided roughly into four geographic areas on the basis of the location and distribution of the major tung-growing areas: (1) Peninsular Florida, (2) northern and western Florida, southern Georgia, and southern Alabama, (3) southern Mississippi and southeastern Louisiana, and (4) western Louisiana and eastern Texas.

## SOILS OF PENINSULAR FLORIDA

### General Considerations

The soils of peninsular Florida are generally more sandy in both upper and lower layers than those in other parts of the tung belt, although there are many sandy sections in the other areas. As is evident from figure 1, most of the tung orchards in this area are located in Alachua County, where the first commercial plantings in the United States were made. The predominant soil types on which tung is being grown in peninsular Florida are Gainesville loamy fine sand and fine sandy loam, Arredondo loamy fine sand and fine sand, Fort Meade loamy fine sand and fine sand, Lakeland fine sand (formerly called Norfolk), Blanton fine sand, Leon fine sand, Scranton loamy fine sand, and Fellowship loamy fine sand and fine sandy loam. All these soils are moderately to strongly acid. The Gainesville, Arredondo, and Fort Meade series are considered satisfactory soils for tung. The Blanton and Lakeland soils have too great a depth of sand to be recommended. Extensive plantings of tung on the Lakeland soil have failed, and one of the reasons is its relatively low productivity level. The Leon, Scranton, and Fellowship soils are much too poorly drained for growing tung trees successfully. Brief

[1] U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, [Division of Soil Survey]. progress report of committee on soil texture. [4] pp., illus. July 20, 1948. [Processed.] (Illustration is entitled "Guide for Textural Classification," dated March 17, 1948.)

descriptions of the different soils are given in the next section. More information can be obtained from a bulletin on the soils of Florida (*8*).[2]

## Brief Descriptions [3]

**Gainesville series.**—Soils of the Gainesville series are well drained and the best of those planted to tung in peninsular Florida. The grayish-brown surface soil is usually loamy fine sand or fine sandy loam which is underlain by a reddish-brown fine sandy loam to sandy clay loam. The soil is formed from beds of unconsolidated fine sands and sandy loams, in some places mixed with residuum from phosphatic limestone.

**Arredondo series.**—Soils of the Arredondo series occur in association with those of the Gainesville series. They also are well drained and suited to tung growing. The brownish-gray surface soil is usually loamy fine sand or fine sand, grading into a light-brown to yellowish-brown loamy fine sand which is underlain by fine sandy loam to sandy clay loam at 2 to 4 feet. The parent material is similar to that from which the Gainesville series was formed.

**Fort Meade series.**—Soils of the Fort Meade series are more sandy than the Gainesville and Arredondo soils, but like them they are well drained and comparatively well suited to tung. The dark-brownish-gray surface soil is loamy fine sand or fine sand, grading into brownish-gray to brown loose fine sand which gets lighter in color with depth. This soil is underlain at 4 to 8 feet by pebble phosphate beds, and a few small impure phosphate pebbles occur throughout the profile.

**Lakeland series.**—This series is characterized by a surface 4 to 6 inches of grayish-brown to gray loose fine sand or sand. This is underlain by 3 to 10 feet or more of light-yellowish-brown to brownish-yellow fine sand or sand which rests on mottled yellow, brown, and light-gray friable fine sandy loam to clay loam. The soils are subject to excessive leaching because of their low content of clay and organic matter. Lakeland is one of the most extensive soil series in peninsular Florida, and considerable tung acreage has been planted on it, largely without success. The trees on it require more care and more fertilization, especially with the minor elements, than do those on the finer textured soils. Consequently, the production costs are higher than on the better soils.

**Blanton series.**—This series is closely related to the Lakeland series, differing from it mainly in that the subsoil is a light-brownish-gray to light-gray loose fine sand underlain at 4 feet or lower by mottled brown, yellow, and gray fine sandy loam to clay loam. It is not so rapidly drained as the Lakeland soils. Like the Lakeland soils, the Blanton soils are marginal for tung growing.

**Leon series.**—This series consists of poorly drained soils of the flatwoods. They are characterized by a well-defined dark-brown to black organic hardpan layer found usually about 12 to 24 inches below the surface. The surface 3 or 4 inches of soil is a dark-gray fine sand with a characteristic salt-and-pepper appearance. This grades into a grayish-white or white subsurface of loose fine sand which rests on the hardpan. These soils are very extensive in peninsular Florida, but they are definitely not recommended for tung.

**Scranton series.**—This series is not suited to tung because of poor drainage; it is somewhat better drained than the Leon series. It is found in association with the Leon series in the flatwoods. The dark-gray to black surface soil may be 10 inches or more in depth. The yellowish-gray subsurface is a loamy sand underlain by a mottled gray and yellow sandy clay.

---

[2] Italic numbers in parentheses refer to Literature Cited, p. 22.

[3] These descriptions are of soils under relatively undisturbed conditions. Much of the information has been taken from descriptions furnished by the Division of Soil Survey, Bureau of Plant Industry, Soils, and Agricultural Engineering. There is always some variation in color, texture, thickness of horizons, and other characteristics within each soil. Some properties of the surface and the subsurface are modified by cultivation. For more detailed information the available county soil survey reports and maps of the U. S. Department of Agriculture can be consulted. The Division of Soil Survey, U. S. Bureau of Plant Industry, Soils, and Agricultural Engineering, and the soils or agronomy departments of the various State agricultural colleges have information on soil classification. The U. S. Department of Agriculture 1938 Yearbook of Agriculture "Soils and Men" is a valuable reference (*22*).

**Fellowship series.**—The surface 6 to 8 inches is a dark- to medium-gray fine sandy loam or loamy fine sand. This is underlain by about 6 inches of a light-gray or light-yellowish-gray fine sandy loam which grades into a gray mottled with red, yellow, and brown heavy plastic clay subsoil. Drainage conditions are similar to those of the Scranton series. Tung has been planted but without success.

## Soil-Type Experiments [4]

In order to get a measure of the difference in productivity of the different soils, soil-type plots were set up in 1940 in 2 locations in peninsular Florida, one near Morriston with 10-year-old trees and the other near Floral City with 7-year-old trees. Two soil types were compared at each location. At Morriston there were 4 replications of 25-tree plots each of Gainesville loamy fine sand and Lakeland fine sand. At Floral City there were 3 replications of 25-tree plots of each of 2 phases of Lakeland fine sand. One phase, designated here as "deep sand phase," is a deep fine sand with no clay beds within 8 feet of the surface; the other, designated here as "shallow sand phase," has a brown sandy clay layer within 3 to 6 feet of the surface.

Insofar as possible the plots selected were in comparable topographic positions. At each location the cultivation and fertilization were the same for both soils so that the only variable was the kind of soil. The yield data for 1940–45 are presented in table 2. As the two locations were under different ownership with different management only the two soils at each location can be compared.

At Morriston the Gainesville soil was considerably more productive than the Lakeland soil. The data were analyzed statistically, and the difference in yield between the two soils was found to be highly significant. At Floral City the average production of the Lakeland fine sand which had a heavy clay layer relatively close to the surface was more than 2½ times as much as that of the soil in which the sand was 8 feet or more deep. These data emphasize the value of a friable clay layer in the subsoil to provide a reservoir of plant nutrients and water. It should be pointed out that the yields are relatively low in these orchards because the trees did not receive adequate cultivation and fertilization. Other orchards on similar soils under better management are much more productive. In addition, still greater yields can be expected by the use of higher yielding varieties now available.

## Physical and Chemical Properties

Representative analyses of soils important in tung production in peninsular Florida are given in table 3. These are adapted from a previous publication (*7*). The base-exchange capacity is a measure of the capacity of a soil to absorb and hold such plant nutrients as calcium, magnesium, and potassium. These nutrient elements are known as exchangeable bases. The amount of clay and organic matter largely determines the exchange capacity of a soil as well as its water-holding capacity. The pH is a measure of the acidity of a soil and is largely determined by the amount of hydrogen absorbed by the exchange

[4] The help of Joseph Hamilton, formerly assistant horticulturist, U. S. Field Laboratory for Tung Investigations, Gainesville, Fla., in obtaining the records in these experiments is gratefully acknowledged.

TABLE 2.—*Yield of air-dry tung fruit per acre on 2 soil types in 2 locations in peninsular Florida, 1940–45*

| Location | Year of planting | Soil type | 1940 | 1941 | 1942 | 1943 | 1944 | 1945 | Average |
|---|---|---|---|---|---|---|---|---|---|
| | | | *Tons* | *Tons* | *Tons* | *Tons* | *Tons* | *Tons* | *Tons* [1] |
| Morriston | 1931 | Gainesville loamy fine sand | 1. 36 | 0. 34 | 0. 43 | 0. 28 | 0. 93 | 0. 60 | 0. 65 |
| | | Lakeland fine sand | . 61 | . 40 | . 23 | . 26 | . 64 | . 30 | . 41 |
| Floral City | 1934 | Lakeland fine sand, "shallow sand phase" | . 36 | . 33 | . 31 | . 05 | . 22 | . 42 | . 28 |
| | | Lakeland fine sand, "deep sand phase" | . 14 | . 15 | . 08 | . 02 | . 09 | . 18 | . 11 |

[1] A ton of air-dry tung fruit yields about 320 pounds of tung oil, which at the market prices in October 1949 was worth about $80. Processing costs averaged about $13.50 a ton. On the 1948 crop, growers who produced less than a ton per acre usually lost money on their operations. In 1948 a ton of air-dry tung fruit was worth about $65.

868901—50—2

TABLE 3.—*Physical and chemical properties of some important soils in peninsular Florida*

| Soil type | Depth | pH | Organic matter | Clay | Base-exchange capacity per 100 gm. of soil | Exchangeable bases per acre | | | Available phosphorus per acre |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Calcium | Magnesium | Potassium | |
| | *Inches* | | *Percent* | *Percent* | *Milliequivalents* | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| Gainesville loamy fine sand | 0–6 | 5. 8 | 3. 0 | 6. 1 | 11. 8 | 1, 216 | 142 | 288 | 152 |
| | 6–20 | 5. 9 | . 9 | 8. 8 | 7. 2 | 824 | 36 | 118 | 120 |
| | 20–60 | 5. 9 | . 6 | 9. 1 | 7. 6 | 952 | 192 | 40 | 172 |
| Arredondo loamy fine sand | 0–6 | 6. 5 | 1. 0 | 4. 4 | 2. 9 | 968 | 38 | 78 | 90 |
| | 6–40 | 5. 8 | . 3 | 6. 0 | 1. 9 | 408 | 13 | 35 | 72 |
| | 40–54 | 5. 2 | . 3 | 25. 4 | 7. 3 | 304 | 28 | 70 | 102 |
| Fort Meade loamy fine sand | 0–6 | 5. 5 | 2. 8 | 4. 1 | 7. 4 | 544 | 68 | 78 | 72 |
| | 6–24 | 5. 6 | 1. 6 | 6. 1 | 4. 9 | 256 | 20 | 78 | 80 |
| | 24–42 | 5. 5 | . 4 | 4. 8 | 3. 9 | 208 | 16 | 102 | 116 |
| Blanton fine sand | 0–7 | 5. 8 | 1. 0 | 3. 3 | 2. 4 | 204 | 22 | 118 | 560 |
| | 7–26 | 5. 5 | . 6 | 2. 3 | 1. 5 | 32 | (1) | 54 | 124 |
| | 26–36 | 5. 6 | . 3 | 2. 7 | . 9 | 4 | (1) | 54 | 80 |
| Lakeland fine sand | 0–6 | 5. 6 | 1. 0 | 3. 2 | 2. 4 | 72 | 22 | 46 | 56 |
| | 6–14 | 5. 7 | . 3 | 2. 4 | 1. 2 | 20 | (1) | 54 | 84 |
| | 14–60 | 5. 7 | . 1 | 2. 7 | 1. 0 | 20 | (1) | 54 | 60 |

[1] Trace.

materials. In soils that are strongly acid, of low pH, the hydrogen predominates and the exchangeable bases are low. The best soils for tung production are those that have a relatively high base-exchange capacity, preferably not less than 5 milliequivalents per 100 gm. of soil, and at least 50 percent of the capacity saturated with exchangeable bases.

The Gainesville, Arredondo, and Fort Meade soils (table 3) are higher in both exchange capacity and exchangeable bases than the Blanton and Lakeland soils; these properties undoubtedly account for their higher productivity. In general the soils range in acidity from slightly to strongly acid. The low organic-matter content of the Blanton and Lakeland soils is characteristic. Also the amount of exchangeable magnesium present is extremely low in the Blanton and Lakeland soils. Magnesium deficiency and minor-element deficiencies are prevalent in the last two soil series.

## Soil Management

The generally low fertility level of even the better soils in peninsular Florida makes it imperative to follow the best soil-management practices. Adequate cultivation, turning under of green-manure crops, and proper fertilization are essential for successful tung orcharding (*16*).

Frequent cultivation in the spring has proved to be especially beneficial for the growth of young trees on sandy soil (*5*). Frequent spring cultivation of the bearing orchard is no less important in order to keep down the grass and weeds, which compete with the trees for moisture and nutrients (*15*). The effects of weed competition are probably more serious on sandy soils than on heavier soils because of the low water- and nutrient-holding capacity of the sandy soils.

Although cultivation is important on the sandy soils during the spring and is necessary in the fall to prepare the land for fruit drop, it is also important to produce a green-manure crop to turn under so as to maintain the organic-matter content of the soil and to help provide nitrogen and mineral nutrients for the trees (*1*). Summer cover crops, such as *Crotalaria intermedia* Kotschy, *C. mucronata* Desv. (formerly *C. striata* DC.), *C. lanceolata* E. Mey. (*17*), hairy indigo (*Indigofera hirsuta* L.), and alyceclover (*Alysicarpus vaginalis* (L.) DC.) (*2*), can be grown successfully. These should be managed so that they will make their growth during the rainy summer months and be turned under by the end of August or early September before fruit drop and before they compete with the trees for moisture during the usual fall drought. Crotalaria self-seeds the whole area if a strip is left in the tree-row middle. The seed of alyceclover must be harvested and replanted, thus requiring more labor than crotalaria.

A winter cover crop may be grown to advantage, as it makes its growth at a time when there is little or no competition with the trees unless there is a spring drought. It has the disadvantages that it must be planted every year and the planting season is limited. Because October is the best planting season, the fruit drop increases the difficulty of operations. At present blue lupine (*Lupinus angustifolius* L.) appears to be the most reliable winter cover crop for tung

orchards on the sandy soils of peninsular Florida (*11*). Yellow lupine (*Lupinus luteus* L.) now under observation and trial is a promising winter cover crop.

## Fertilization

In addition to nitrogen, phosphorus, and potassium the fertilizer mixture usually should supply magnesium and zinc and often copper and manganese to some soils planted to tung orchards in peninsular Florida. After growth has started in the spring, newly planted trees should receive about 0.06 to 0.08 pound of nitrogen (N), 0.04 to 0.06 pound of phosphoric acid ($P_2O_5$), 0.06 pound of potash ($K_2O$), 0.03 to 0.04 pound of magnesium oxide (MgO), and 0.03 to 0.08 pound of zinc oxide (ZnO). The last two materials should be applied in the sulfate form. One suggested formula, 6–6–6–3(MgO)–3(ZnO), at the rate of 1 pound per tree has proved satisfactory on many of the light-textured soils. Often this has to be supplemented with an additional ounce or two per tree of zinc sulfate where zinc deficiency is prevalent. In some orchards it is feasible to spray the young trees with a mixture of about 5 pounds of zinc sulfate and 3 pounds of lime in 100 gallons of water.

Where copper and manganese are needed, 0.01 to 0.02 pound of copper oxide (CuO) and 0.01 to 0.02 pound of manganese oxide (MnO) per tree in the sulfate form should suffice. If desired, a solution of these elements can also be sprayed on the trees along with the zinc in a mixture containing 4 pounds of zinc sulfate, 4 pounds of manganese sulfate, 4 pounds of copper sulfate, and 6 pounds of lime in 100 gallons of water. On soils that are low in copper a high-nitrogen application will accentuate copper deficiency (*3*).

With each additional year of age of the trees an additional pound of fertilizer is required until they reach about 12 years of age, when the amount of fertilizer can be leveled off at about 12 pounds per tree. The percentage of the various elements in the mixture, however, will change with increasing age of the tree.

If good soil-management practices have been followed, a 10-year-old orchard, for example, will require as minima for good production about 1 pound of N, 0.50 pound of $P_2O_5$, 1 pound of $K_2O$, 0.30 pound of MgO, 0.05 to 0.10 pound of ZnO, 0.05 pound of CuO, and 0.05 to 0.10 pound of MnO per tree. The minor elements should be supplied in the sulfate form. Ten pounds of a 10–5–10–3(MgO)–0.75(ZnO)–0.50(CuO)–0.50(MnO) mixture would meet this requirement, or 12½ pounds of an 8–4–8 formula with the proper amounts of the minor elements. Ordinarily, fertilizers of the formulas just suggested are not available, but the grower should attempt to procure materials to provide approximately what is needed by the trees.

Many bearing orchards on the Blanton, Lakeland, and Leon fine sands and related poorly drained soils have suffered from severe magnesium deficiency (*4*). The trouble has been caused by failure to apply sufficient magnesium in the early years of the orchard or by adding too much potassium to the trees in the form of commercial fertilizer or tung hulls. To correct a serious deficiency it is necessary to avoid applying excessive potassium and to apply 2 to 4 pounds of epsom salts (hydrated magnesium sulfate) or an equivalent amount of other soluble magnesium salts per tree per year for several years.

However, when the deficiency has been remedied, it is preferable to maintain the magnesium supply by applying the more slowly available dolomite.

## SOILS OF NORTHERN AND WESTERN FLORIDA, SOUTHERN GEORGIA, AND SOUTHERN ALABAMA

### General Considerations

The predominant upland soil types considered important for tung production in the second area are loamy sands and sandy loams of the following series: Red Bay, Ruston, Norfolk, Marlboro, Tifton, Faceville, Carnegie, Orangeburg, Greenville, and Magnolia. All of these soils are well suited to tung growing, and some of the most productive orchards of the tung belt are on them. Most of the present plantings in Jefferson and Leon Counties, Fla., Thomas, Grady, and Decatur Counties, Ga., and Baldwin and Mobile Counties, Ala., are on these soils. A considerable acreage of tung is planted on Lakeland and Eustis soils in Jackson, Calhoun, Walton, and Okaloosa Counties in western Florida, but it is questionable whether most of the trees will be profitable in comparison with those on other soils that are better suited. Some acreage in this area is planted on Susquehanna fine sandy loam, which is unsuitable because of the heavy plastic clay subsoil which makes drainage poor.

The topography associated with these soils is undulating to rolling. The soils have been developed from noncalcareous marine deposits of sand and clays except for the Greenville, Magnolia, and Faceville soils, which are locally influenced by limestones.

### Brief Descriptions [5]

**Red Bay series.**—The brown to dark-brown surface soil of about 4 inches ranges in texture from loamy sand or loamy fine sand to sandy loam or fine sandy loam. The reddish-brown subsurface is either loamy sand or sandy loam in texture. The subsoil, which is usually at least 4 feet thick, is red friable fine sandy clay loam to sandy clay. The substratum is red friable sandy clay slightly streaked with yellow and gray. The Red Bay soils are excellent for tung production, though special attention must be given to potash fertilization especially when the trees come into bearing.

**Ruston series.**—The brownish-gray to grayish-brown surface soil of about 3 to 4 inches ranges in texture from loamy sand or loamy fine sand to sandy loam or fine sandy loam. The brownish-yellow to yellowish-brown subsurface is a loamy sand or sandy loam. The subsoil, which is usually 3 feet or more thick, is yellowish-red to reddish-yellow sandy clay loam. The Ruston soils, like the Red Bay, are among the best for tung production and require about the same culture and fertilization. (See 11-year-old orchard on Ruston fine sandy loam shown on cover.)

**Norfolk series.**—The gray surface soil of about 3 to 4 inches is usually loamy sand or loamy fine sand. The pale-yellow subsurface, about 12 inches thick, is loamy fine sand or loamy sand to fine sandy loam or sandy loam. The subsoil down to a depth of 3 feet or more is yellow to light-yellowish-brown friable fine sandy clay loam or sandy clay loam. The substratum is usually composed of mottled yellow, brown, gray, and red sandy clay loams. The Norfolk series rates almost as high for tung production as the Red Bay and Ruston soils and requires about the same management.

---

[5] See footnote 3, p. 5.

**Marlboro series.**—This series is closely related to the Norfolk but differs from it primarily in having more clay and less sand throughout its depth. The surface soil is usually sandy loam or fine sandy loam. The subsoil is usually yellowish-brown friable sandy clay or fine sandy clay. The productivity of tung is about the same as on the Norfolk soils.

**Tifton series.**—Soils of the Tifton series are closely related to the Norfolk and Marlboro soils but differ from them primarily in having a large amount of small, rounded, brown or black pebbles on the surface and mixed throughout the profile. The color and texture of the various layers are similar to those of the Marlboro soils. The productivity of tung is about the same as on the Norfolk and Marlboro soils.

**Faceville series.**—This series is closely related to the Ruston but differs essentially from it in that its surface soil is darker brown and more clay is present in the various layers. The subsoil is sandy clay as is the substratum, while the Ruston has a sandy clay loam subsoil and substratum. The productivity of tung is about the same as on Ruston soils.

**Carnegie series.**—This series is similar to the Faceville but is distinguished from it primarily by the presence of a large quantity of small, rounded, brown or black pebbles throughout the profile.

**Orangeburg series.**—This series is similar to the Red Bay but differs from it in having brownish-gray to pale-yellow surface layers rather than brown and in having a lighter red subsoil. The Orangeburg soils, like the Red Bay, are excellent for tung production.

**Greenville series.**—Soils of the Greenville series are similar to the Red Bay soils but differ in having more clay throughout the profile, especially in the lower layers. They rate among the highest for tung production.

**Magnolia series.**—This series is similar to the Orangeburg but has more clay throughout the profile especially in the lower layers. Soils of the Magnolia series are among the best soils for tung.

**Lakeland series.** [6]

**Eustis Series.**—Soils of the Eustis series are similar to the Lakeland soils but differ primarily in color and in having more clay in some places. The surface 4 inches is reddish-brown to brown loose sand, fine sand, loamy fine sand, or loamy sand. The subsurface, extending to a depth of 5 feet or more, is reddish-brown to reddish-yellow loose sand, fine sand, loamy fine sand, or loamy sand. These soils, like the Lakeland soils, are excessively drained. Because of their sandy character, they do not have the potentialities for tung production that the heavier soils in the area have.

**Susquehanna series.**—This series is characterized by the heavy, mottled red, yellow, and brown subsoil, which is plastic and sticky when wet and hard when dry. The gray to light-brownish-gray surface soil is sandy loam, fine sandy loam, or sandy clay loam. In many places erosion has removed all or part of the sandy surface, exposing the mottled clay at the surface. The Susquehanna soils are definitely unsuited to growing tung.

## Physical and Chemical Properties

Representative analyses of soils important in tung production in northern and western Florida, southern Georgia, and southern Alabama are given in table 4. These are adapted from a previous publication (*7*) and some unpublished data. The terms used in the table are discussed on page 6.

These analyses indicate the general character of the soils of this area. The organic-matter content of the surface soil ranges from 1 percent to almost 2.5 percent. The clay content is usually much higher in the subsoil and substratum than in the surface and subsurface layers, and in all cases the subsoil has at least 20 percent of clay. The amount of exchangeable bases and available phosphorus is representative. It is noted that some soils are very low in potassium, and potassium deficiency is one of the major nutritional problems in the

[6] See p. 5.

TABLE 4.—*Physical and chemical properties of some important soils in northern and western Florida, southern Georgia, and southern Alabama*

| Soil type | Depth | pH | Organic matter | Clay | Base-exchange capacity per 100 gm. of soil | Exchangeable bases per acre | | | Available phosphorus per acre |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Calcium | Magnesium | Potassium | |
| | *Inches* | | *Percent* | *Percent* | *Milliequivalents* | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| Red Bay loamy fine sand | 0–6 | 5. 6 | 1. 0 | 9. 9 | 3. 4 | 236 | 46 | 28 | 13 |
| | 6–16 | 5. 8 | . 3 | 18. 9 | 3. 3 | 624 | 94 | 16 | 18 |
| | 16–60 | 5. 8 | . 3 | 27. 5 | 4. 4 | 680 | 122 | 20 | 21 |
| Ruston fine sandy loam | 0–5 | 5. 7 | 2. 1 | 10. 0 | 5. 8 | 1, 185 | 82 | 84 | 25 |
| | 5–11 | 5. 7 | . 5 | 15. 8 | 4. 4 | 872 | 88 | 42 | (1) |
| | 11–48 | 5. 2 | . 2 | 20. 0 | 4. 8 | 918 | 64 | 40 | (1) |
| Norfolk fine sandy loam | 0–6 | 5. 6 | 1. 9 | 14. 0 | 5. 1 | 484 | 36 | 42 | 5 |
| | 6–12 | 5. 1 | . 4 | 30. 8 | 3. 5 | 140 | 28 | 74 | (1) |
| | 12–36 | 5. 2 | . 3 | 27. 4 | 3. 6 | 268 | 44 | 78 | (1) |
| Orangeburg sandy loam | 0–6 | 5. 6 | 2. 4 | 9. 4 | 5. 2 | 438 | 54 | 128 | (1) |
| | 6–30 | 5. 4 | . 7 | 11. 5 | 2. 5 | 158 | 46 | 70 | (1) |
| | 30–40 | 5. 2 | . 4 | 22. 2 | 3. 4 | 122 | 46 | 64 | (1) |
| Faceville fine sandy loam | 0–6 | 5. 6 | 1. 2 | 7. 4 | 3. 8 | 380 | 32 | 80 | 20 |
| | 6–16 | 5. 5 | . 5 | 11. 4 | 3. 0 | 340 | 50 | 40 | 36 |
| | 16–34 | 5. 5 | . 5 | 41. 4 | 8. 7 | 1, 284 | 110 | 24 | 10 |

[1] Trace.

area. The available phosphorus of most of these soils is very low, which points up the need for phosphate fertilization, especially in connection with the cover-crop program. The soils are moderately to strongly acid, indicating the necessity of a liming program.

## Soil Management

The same principles of soil management apply to the soils of northern and western Florida, southern Georgia, and southern Alabama as to those of peninsular Florida. Frequent spring cultivation or mulching of newly transplanted trees produces the best growth (*12*).

Producing and turning under a green-manure crop is as beneficial in tung orchards in this area as in the sandier soils of peninsular Florida. The same summer and winter cover crops can be grown. In addition there are several winter cover crops that can be grown more successfully in this area than in peninsular Florida, such as hairy vetch (*Vicia villosa* Roth) and Austrian Winter peas (*Pisum sativum* L.).

As phosphorus is generally low in these soils, which also are moderately to strongly acid, it is necessary to apply superphosphate and lime as well as potassium for best results with the cover crop. Basic slag at 300 to 500 pounds per acre or 200 to 300 pounds of 20-percent superphosphate plus 500 pounds of dolomitic lime is recommended. Muriate of potash at a rate of 50 to 100 pounds per acre is usually adequate.

## Fertilization

For the sandy soils in the area, especially those in Jackson, Calhoun, Walton, and Okaloosa Counties in western Florida, the fertilizer requirements are similar to those in peninsular Florida, and these are discussed on page 10.

Magnesium deficiency is especially prevalent on the deep sandy soils of this area. On the heavier soil types of the area, such as the Red Bay, Ruston, Norfolk, and associated soils, the fertilizer requirements are somewhat different. The minor elements other than zinc are apparently present in sufficient amounts in these soils as indicated by minor-element experiments and by leaf analyses. Zinc is commonly deficient in these soils, but not always so. As it is an expensive fertilizer element, it should be added to only those soils for which experience has shown that it is needed.

One of the major nutritional problems of the area has been potassium deficiency. It was first found in trees on Red Bay fine sandy loam soil in northern Florida (*6*) and, later, on the same soil and on related soils in southern Georgia, western Florida, and southern Alabama. What had been considered to be an adequate amount of potash in the mixed fertilizer that was used proved entirely insufficient. In addition to retarding growth and limiting production, potassium deficiency was found to reduce materially the percentage of oil in the fruit.

For young trees in this area mulching has proved to be beneficial (*13*). In addition to being a good source of potassium, an organic mulch helps to conserve moisture.

For older bearing trees at least 1 pound of potash ($K_2O$) per tree, in addition to 1 pound of nitrogen (N) and 0.50 pound of phosphoric acid ($P_2O_5$), is required to maintain good growth and high produc-

tion. In several experiments in this area it has been found that nitrogen fertilization tends to accentuate potassium deficiency, and for high production in potassium-deficient bearing orchards 2 pounds of $K_2O$ is required for every pound of N (*14*).

## SOILS OF SOUTHERN MISSISSIPPI AND SOUTHEASTERN LOUISIANA

### General Considerations

The predominant soils of the upland in southern Mississippi and southeastern Louisiana that are important in tung production include the following series: Ora, Dulac, Savannah, Franklinton, Pheba, Lew-

FIGURE 2.—Five-year-old tung trees making satisfactory growth on Dulac very fine sandy loam soil under good management.

iston, Bowie, Shubuta, Norfolk, Ruston, Orangeburg, Red Bay, Carnegie, and Tifton. Large acreages of tung are found also on Susquehanna soils, especially in Perry and Greene Counties in Mississippi. As stated earlier, these soils are decidedly unsuited to growing tung and many plantings on these soils have been abandoned and others are about to be. The Caddo series has also been planted to tung, but the trees eventually die because of the poor drainage.

Large acreages of tung have been planted on Ora, Dulac, Savannah, Franklinton, Pheba, and Lewiston soils, although these are not necessarily the most extensive soils of the area. The Ora, Dulac, Savannah, and Franklinton soils have proved satisfactory for successful

tung production (fig. 2), although they are not so productive as some of the others. The Pheba and Lewiston soils have been found to be unsuited because of a hardpan layer within 12 to 30 inches of the surface, which results in poor drainage (fig. 3).

FIGURE 3.—Five-year-old tung trees making unsatisfactory growth on Lewiston very fine sandy loam soil under same culture as trees in figure 2.

## BRIEF DESCRIPTIONS [7]

Norfolk, Ruston, Orangeburg, Red Bay, Carnegie, and Tifton series have already been described on pages 11 and 12.

**Ora series.**—The surface 6 to 8 inches is grayish-brown to brown fine sandy loam or sandy loam, grading into a yellowish-brown subsurface about 6 inches thick. The subsoil is reddish-yellow to reddish-brown friable sandy clay and varies from 12 to 24 inches in thickness. This layer rests on mottled red, brown, yellow, and gray sandy clay, which is highly compacted and in most places weakly cemented. Tung production is high, but not so high as on the Ruston, Red Bay, and other closely related soils.

**Dulac series.**—Soils of the Dulac series are very similar to the Ora soils but are derived from a thin layer of loessial silt over the acid marine sediments from which the Ora soils are formed. Consequently those of the Dulac series contain a much higher percentage of silt in the surface and subsoil layers than the Ora. The productivity of tung on these is about the same as on the Ora soils.

**Savannah series.**—Soils of the Savannah series are associated with the Ora soils. They occupy level to gently undulating topographic positions, whereas the Ora soils are usually found on the slopes. Consequently Savannah soils are not quite so well drained as the Ora. The surface 6 inches is grayish-brown very fine sandy loam to sandy loam. The subsoil down to a depth of about 30 to 36 inches is yellowish-brown to brownish-yellow sandy clay loam. This is underlain by mottled gray, yellow, and red sandy clay loam containing a few soft iron pebbles. This layer is firmly cemented when dry and soft when wet. The Savannah soils are satisfactory for tung production but probably are a little less suited than the Ora and Dulac soils.

**Franklinton series.**—Soils of the Franklinton series are similar to the Savannah soils but are derived from a thin layer of loessial silt over the acid marine sediments from which the Savannah series is formed. Consequently they contain a much higher percentage of silt in the surface and subsoil layers than the Savannah soils. The productivity of tung is about the same as on the Savannah soils.

[7] See footnote 3, p. 5.

**Pheba series.**—Soils of the Pheba series are associated with the Savannah series. They occupy the flat ridge tops and are consequently more poorly drained than the Savannah soils. The brownish-gray to dark-gray surface is very fine sandy loam to sandy loam. The subsoil to a depth of about 18 inches is pale-yellow sandy clay loam faintly mottled with shades of yellow and brown. This is underlain by a mottled yellow, gray, and brown sandy clay loam, which is firmly cemented when dry and soft when wet and contains numerous soft iron concretions. Because of the hardpan layer which restricts drainage in the lower subsoil, the Pheba soils have not been satisfactory for growing tung.

**Lewiston series.**—Soils of the Lewiston series are very similar to the Pheba soils but are derived from a shallow layer of loessial silt over the acid marine sediments from which the Pheba soils are formed. Like the Pheba, the Lewiston soils are not satisfactory for tung production.

**Bowie series.**—Soils of the Bowie series resemble those of the Savannah series. The essential difference between them is that the Bowie soils do not have the cementation in the lower subsoil. Also the Bowie soils usually have distinct splotches of red in the lower subsoil, whereas red splotches are rarely found in the Savannah soils.

**Shubuta series.**—The surface 3 to 6 inches of the Shubuta soils is brownish-gray fine sandy loam to very fine sandy loam, grading into yellow to yellowish-brown fine to very fine sandy loam. The subsoil, which is about 18 to 25 inches thick, is brown to reddish-brown clay to silty clay, moderately plastic when wet and moderately friable when dry. This grades into the substratum, which is a mottled brown, reddish-brown, gray, and yellowish-gray compact silty clay. These soils, though very susceptible to sheet erosion, are satisfactory for tung production.

**Caddo series.**—This series is characterized by a very poorly drained soil and is usually found on the flats or slight depressions associated with the Pheba soil. The gray surface soil is fine or very fine sandy loam to silt loam which gets lighter in color with depth, becoming almost white. The subsoil is light-gray sandy clay loam mottled with yellow and brown, firmly cemented when dry and soft when wet.

## Soil-Type Experiments [8]

Soil-type experiments were set up in 1939 in southern Mississippi and southeastern Louisiana in 4 orchards in which some of the main soil types of the area were studied. The trees ranged from 1 to 3 years of age when the experiments were started. The soil types were represented by at least 2, and generally 3, plots of 25 trees each; and many of them were represented in 2 or 3 different orchards. The original plan was to run the experiment for 5 years. Although there were differences in cultural practices and age of trees between the different orchards, it was found upon analyzing the data that a comparison of the soil types within each orchard was not especially advantageous over a general comparison. The data for the average annual yield for the period 1939–43 are given in table 5.

As might be anticipated, the poorly drained Caddo soil is by far the least productive. Only 18 of the 50 original trees in the experiment on this soil were living by the end of the experiment. The Pheba soil, which is also poorly drained, ranks next to the Caddo in low productivity. The most productive soils in this experiment were the Ora and Savannah soils. Although these soils have compact layers, these layers are apparently deep enough so that the drainage is adequate for tung trees. The Shubuta and Norfolk soils rank next in suitability. Ordinarily the Norfolk sandy loam is one of the most productive soils for tung, but in this particular experiment it did not do so well as the Ora and Savannah soils.

[8] The help of Benjamin G. Sitton, horticulturist, U. S. Field Laboratory for Tung Investigations, Bogalusa, La., and Howard Ellison and Lamar Moore, formerly of that laboratory, in obtaining the data in these experiments is gratefully acknowledged.

TABLE 5.—*Yield of air-dry tung fruit per acre on representative soil types in various orchards in southern Mississippi and southeastern Louisiana, 1939–43*

| Soil type | Year of planting | Average yield |
|---|---|---|
| | | *Tons* [1] |
| Ora very fine sandy loam | 1936 and 1938 | 0. 26 |
| Savannah very fine sandy loam | 1936 and 1938 | . 25 |
| Shubuta fine sandy loam | 1936 | . 19 |
| Ora very fine sandy loam, shallow phase [2] | 1936 | . 18 |
| Norfolk sandy loam | 1936 | . 18 |
| Pheba very fine sandy loam | 1936 | . 14 |
| Caddo very fine sandy loam | 1936 | . 02 |

[1] See footnote 1, table 2.
[2] The heavy mottled compact layer is at less than 24 inches below the surface.

It will be noted that in general the yields are low in this experiment even on the better soils. This is due to the fact that the trees were relatively young and did not receive adequate cultivation and fertilization in the early years. Some additional yield data were obtained on certain soils in two locations in 1946 and 1947 (table 6). Although all the yields are considerably higher for these 2 years, the previous conclusions are confirmed. The Ora and Savannah soils are about equally productive, except that the 1947 yield on the Savannah soil at Bush, La., is somewhat lower than that on Ora at that location in that year. Both of these soils, however, are considerably more productive than the poorly drained Pheba soil.

TABLE 6.—*Yield of air-dry tung fruit per acre on representative soil types in southern Mississippi and southeastern Louisiana, 1946–47*

| Location | Year of planting | Soil type | Average yield | |
|---|---|---|---|---|
| | | | 1946 | 1947 |
| | | | *Tons* | *Tons* [1] |
| Bush, La. | 1936 | Ora very fine sandy loam | 1. 52 | 1. 41 |
| | | Savannah very fine sandy loam | 1. 52 | 1. 07 |
| Enon, Miss. | 1938 | Ora very fine sandy loam | 1. 31 | 1. 21 |
| | | Savannah very fine sandy loam | 1. 28 | 1. 12 |
| | | Pheba very fine sandy loam | . 51 | . 45 |

[1] See footnote 1, table 2.

## PHYSICAL AND CHEMICAL PROPERTIES

Representative analyses of soils important in tung production in southern Mississippi and southeastern Louisiana are given in table 7. These are adapted from a previous publication (7) and some previously unpublished data. The terms used in the table are discussed on page 6.

The ranges in pH, organic-matter content, and clay content of these soils approximate those of southern Alabama, southern Georgia, and northern and western Florida. Both exchangeable magnesium and

TABLE 7.—*Physical and chemical properties of some important soils in southern Mississippi and southeastern Louisiana*

| Soil type | Depth | pH | Organic matter | Clay | Base-exchange capacity per 100 gm. of soil | Exchangeable bases per acre | | | Available phosphorus per acre |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Calcium | Magnesium | Potassium | |
| | *Inches* | | *Percent* | *Percent* | *Milliequivalents* | *Pounds* | *Pounds* | *Pounds* | *Pounds* |
| Ora very fine sandy loam | 0–7 | 5. 6 | 2. 5 | 10. 8 | 6. 3 | 464 | 150 | 110 | [1] |
| | 7–30 | 5. 2 | . 4 | 24. 8 | 7. 2 | 196 | 164 | 78 | [1] |
| | 30–40 | 5. 1 | . 3 | 25. 2 | 6. 3 | 72 | 112 | 132 | [1] |
| Pheba very fine sandy loam | 0–5 | 5. 6 | 3. 2 | 10. 8 | 8. 8 | 352 | 114 | 142 | [1] |
| | 5–10 | 5. 6 | 1. 0 | 26. 2 | 6. 2 | 248 | 114 | 112 | [1] |
| | 10–30 | 5. 6 | . 5 | 27. 6 | 9. 5 | 148 | 188 | 112 | [1] |
| Savannah very fine sandy loam | 0–5 | 5. 6 | 2. 8 | 8. 6 | 8. 2 | 886 | 210 | 158 | [1] |
| | 5–12 | 5. 5 | . 8 | 15. 8 | 8. 8 | 652 | 196 | 136 | [1] |
| | 12–36 | 5. 1 | . 5 | 29. 2 | 8. 6 | 284 | 198 | 138 | [1] |
| Shubuta fine sandy loam | 0–5 | 5. 5 | 3. 1 | 7. 6 | 8. 0 | 452 | 68 | 122 | [1] |
| | 5–12 | 5. 5 | . 8 | 9. 6 | 4. 5 | 192 | 40 | 80 | [1] |
| | 12–36 | 5. 3 | . 4 | 33. 6 | 10. 5 | 388 | 190 | 90 | [1] |
| Ruston fine sandy loam | 0–6 | 5. 7 | 1. 9 | 9. 8 | 5. 6 | 582 | 144 | 180 | [1] |
| | 6–12 | 5. 4 | . 6 | 13. 5 | 4. 2 | 484 | 102 | 120 | [1] |
| | 12–40 | 5. 1 | . 3 | 23. 7 | 6. 6 | 348 | 112 | 102 | [1] |
| Norfolk sandy loam | 0–6 | 5. 5 | 1. 6 | 7. 1 | 5. 0 | 640 | 120 | 142 | [1] |
| | 6–12 | 5. 4 | . 5 | 11. 1 | 2. 8 | 376 | 92 | 128 | [1] |
| | 12–36 | 5. 2 | . 3 | 18. 4 | 5. 6 | 176 | 144 | 138 | [1] |

[1] Trace.

potassium run higher in soils of this area than in other parts of the tung belt, but the available phosphorus is lower. Only a trace of phosphorus was found in these soils as determined by dilute-acid extraction. Young tung trees and cover crops give excellent responses to phosphate fertilization.

## Soil Management

The soil-management program for tung orchards in southern Mississippi and southeastern Louisiana follows the same general principles discussed for the other areas. More detailed information is given in a recent bulletin (*9*). Winter cover crops can be grown successfully in this area, although there are some disadvantages in the practice. They have to be planted every year, and after several years the yield of green manure drops off considerably. The common white clover (*Trifolium repens* L.) is a promising winter cover crop that finds favor with some growers.

The extremely low phosphorus content of the soils and the strong acidity of many of them make it necessary to apply superphosphate and lime for growing cover crops. Basic slag at 300 to 500 pounds per acre or 200 to 300 pounds of 20-percent superphosphate plus 500 pounds of lime is recommended.

## Fertilization

As in the other areas annual applications of fertilizer along with the cover-crop program are necessary to maintain high production of tung. Nitrogen (N), phosphoric acid ($P_2O_5$), and potash ($K_2O$) are used in various proportions depending on conditions, and zinc is needed in many locations.

For young trees applications of phosphorus and nitrogen are especially important, as the soils are particularly deficient in these elements (*10*, *19*). The first year 1 pound per tree of an 8–8–4 fertilizer mixture has proved satisfactory. Where zinc is needed, 1 to 2 ounces of zinc sulfate per tree is used. For each successive year of age an additional pound of mixed fertilizer is recommended, but ordinarily the amount of zinc sulfate added does not have to be increased. Also, as the trees get older and come into bearing, less phosphorus, more nitrogen, and as much potassium as nitrogen are required.

Fertilizer experiments conducted in Mississippi and Louisiana have shown that the highest production and lowest cost of production per ton of fruit have come from liberal fertilization of the bearing trees. A high level of nitrogen has been found to increase greatly the yield of fruit and to a lesser extent the percentage of oil in the fruit (*20*). Also, it has been found that the full response to nitrogen is not obtained unless the trees receive adequate phosphorus (*18*). When the trees are brought into heavy production by the use of liberal amounts of nitrogen and phosphorus, there is a big drain on the potassium reserves in the soil and more potash needs to be applied to maintain the trees in good vigor (*21*). Too low a potassium level reduces greatly the percentage of oil in the fruit, resulting in a loss in the value of the fruit.

For bearing trees, 10 years of age or older under good culture on the better soils in southern Mississippi and southeastern Louisiana, 1 pound of N, 0.50 pound of $P_2O_5$, and 0.75 to 1 pound of $K_2O$ have given good results.

## SOILS OF WESTERN LOUISIANA AND EASTERN TEXAS

As shown by table 1, a relatively small acreage of tung has been planted in western Louisiana, mostly in Beauregard Parish, and in eastern Texas, in Jasper, Hardin, and Tyler Counties. There is a total of about 1,500 acres in this area. Part of this acreage is on the better upland soils, such as Norfolk, Ruston, Kirvin, and related series; another part is on Bowie and similar soils of intermediate productivity; and the rest is on such poorly drained soils as Lufkin, Caddo, and Susquehanna.

Well-managed orchards that are located in the upland on soils of the Norfolk, Ruston, Kirvin, and related series have done well. In western Louisiana and eastern Texas there are extensive areas of these soils that are suitable for tung production. On the other hand, there are also large parts of the poorly drained soils such as Caddo and Susquehanna on which tung will not succeed.

## COMPARATIVE VALUE OF DIFFERENT SOILS FOR TUNG PRODUCTION

It has been found that the best soils for tung production are of the following series: Ruston, Red Bay, Orangeburg, Norfolk, Magnolia, Marlboro, Greenville, Faceville, Tifton, and Carnegie. All of these are well-drained upland soils with a relatively sandy surface and subsurface and a sandy-clay-loam to sandy-clay, friable, uniformly colored subsoil. The best records of commercial production of seedling trees have been obtained from orchards located on some of these soils (fig. 4).

In one 600-acre seedling orchard under good management in northern Florida planted in 1931–36 on soils predominantly of the Ruston, Red Bay, Marlboro, Norfolk, and Faceville series, the average yearly production from 1944 to 1948, inclusive, exceeded 2 tons of air-dry fruit per acre. On a well-managed 70-acre orchard in Mississippi planted in 1936 on predominantly Ruston fine sandy loam soil with some Ora, Norfolk, and Bowie soils, the average annual production from 1944 to 1948 approximated 2½ tons per acre.

It should be emphasized that this level of production is obtained on these soils only if the orchards receive good management. In many instances production has been low on the best soils because of lack of adequate cultivation, fertilization, or both. Average annual yields of only one-half ton of air-dry fruit per acre were obtained during the years 1944–48 from poorly managed orchards on Ruston, Faceville, and Red Bay soils.

The Ora and Savannah soils on which a large acreage of tung has been planted in Louisiana and Mississippi are productive soils for tung, but probably will not reach the high level of productivity of the Ruston and related soils.

Orchards located on the sandy soils in peninsular Florida have not produced so well as those on the heavier soils, even when they have received good management. In one 1,200-acre well-managed orchard located on soils predominantly of the Lakeland and Blanton series, the average annual production from 1944 to 1948 was about 1 ton of air-

FIGURE 4.—Ten-year-old tung trees on Norfolk fine sandy loam and closely related soils produce 2 tons or more of tung fruit per acre under good management.

dry fruit per acre. Obviously this level of production does not approach the level produced by the heavier soils under comparable management.

As has been emphasized before, the poorly drained soils such as the Caddo, Susquehanna, Leon, Scranton, and Pheba soils are not suitable for tung. Commercial orchards on these soils have had poor production records even under good management.

## LITERATURE CITED

(1) BLACKMON, G. H., and BARNETTE, R. M.
1936. A COVER CROP PROGRAM FOR FLORIDA PECAN ORCHARDS. Fla. Agr. Expt. Sta. Bul. 297, 44 pp., illus.

(2) BLASER, R. E., RITCHEY, G. E., and STOKES, W. E.
1942. ALYCE CLOVER. Fla. Agr. Expt. Sta. Press Bul. 570, [4] pp.

(3) DICKEY, R. D., DROSDOFF, M., and HAMILTON, J.
1948. COPPER DEFICIENCY OF TUNG IN FLORIDA. Fla. Agr. Expt. Sta. Bul. 447, 32 pp., illus.

(4) DROSDOFF, M., and KENWORTHY, A. L.
1944. MAGNESIUM DEFICIENCY OF TUNG TREES. Amer. Soc. Hort. Sci. Proc. 44: 1–7, illus.

(5) ——— NEFF, M. S., and MERRILL, S., Jr.
1947. IMPORTANCE OF CULTIVATING TUNG TREES IN THEIR FIRST YEAR IN THE ORCHARD. Amer. Tung Oil Assoc. Proc. 13: 58–64. [Processed.]

(6) ——— and PAINTER, J. H.
1942. A CHLOROSIS AND NECROSIS OF TUNG LEAVES ASSOCIATED WITH LOW POTASSIUM CONTENT. Amer. Soc. Hort. Sci. Proc. 41: 45–51, illus.

(7) DYAL, R. S., and DROSDOFF, M.
1944. PHYSICAL AND CHEMICAL PROPERTIES OF SOME IMPORTANT SOILS OF THE SOUTHEAST USED FOR THE PRODUCTION OF TUNG OIL. Soil Sci. Soc. Amer. Proc. (1943) 8: 317–322.
(8) HENDERSON, J. R.
1939. THE SOILS OF FLORIDA. Fla. Agr. Expt. Sta. Bul. 334, 67 pp., illus.
(9) KILBY, W. W., and POTTER, G. F.
1949. TUNG CULTURE IN SOUTHERN MISSISSIPPI. Miss. Agr. Expt. Sta. Bul. 464, 35 pp., illus. (Revised.)
(10) LAGASSE, F. S., ANGELO, E., BAHRT, G. M., and others.
[1944.] MINERAL NUTRITION PROBLEMS OF AMERICAN TUNG ORCHARDS. Amer. Tung Oil Assoc. [Proc.] 10: 1–8. [Processed.]
(11) MCKEE, R., and RITCHEY, G. E.
1947. LUPINES: NEW LEGUMES FOR THE SOUTH. U. S. Dept. Agr. Farmers' Bul. 1946, 10 pp., illus. (Revised.)
(12) NEFF, M. S., and POTTER, G. F.
1946. FACTORS AFFECTING GROWTH OF NEWLY TRANSPLANTED TUNG TREES DURING DRY WEATHER. Amer. Tung Oil Assoc. Proc. [12] (1): 47–[53]. [Processed.]
(13) PAINTER, J. H.
1947. MULCHING YOUNG TUNG TREES PAYS DIVIDENDS. Amer. Tung Oil Assoc. Proc. 13: 36–41. [Processed.]
(14) ——— DROSDOFF, M., and BROWN, R. T.
1948. RESPONSES OF BEARING TUNG TREES ON RED BAY FINE SANDY LOAM TO POTASSIUM AND NITROGEN. Amer. Soc. Hort. Sci. Proc. 52: 19–24.
(15) POTTER, G. F.
1946. ORCHARD CULTIVATION BY A TESTED METHOD. Amer. Tung Oil Assoc. Proc. [12] (2): 15–17. [Processed.]
(16) ——— PAINTER, J. H., BAHRT, G. M., and others.
[1944.] SOIL MANAGEMENT IN TUNG ORCHARDS OF THE UNITED STATES. Amer. Tung Oil Assoc. [Proc.] 10: [9]–17. [Processed.]
(17) RITCHEY, G. E., MCKEE, R., BECKER, R. B., and others.
1941. CROTALARIA FOR FORAGE. Fla. Agr. Expt. Sta. Bul. 361, 72 pp., illus.
(18) SITTON, B. G.
1948. RESPONSE OF BEARING TUNG TREES TO NITROGEN, PHOSPHORUS, AND POTASSIUM FERTILIZERS. Amer. Soc. Hort. Sci. Proc. 25: 25–39.
(19) ———
1949. THE EFFECT OF NITROGEN, PHOSPHORUS, AND POTASSIUM UPON THE GROWTH OF NEWLY TRANSPLANTED TUNG TREES. Amer. Soc. Hort. Sci. Proc. 54: 22–28.
(20) ——— and LOUSTALOT, A. J.
[1945.] NITROGEN PROMPTLY INCREASES YIELDS OF TUNG OIL. Amer. Tung Oil Assoc. Proc. [11]: 10–15. [Processed.]
(21) ——— PAINTER, J. H., and BROWN, R. T.
1948. INCREASING PROFITS FROM TUNG ORCHARDS WITH POTASSIUM. Amer. Tung Oil Assoc. Proc. 14: 16–20. [Processed.]
(22) UNITED STATES DEPARTMENT OF AGRICULTURE.
1938. SOILS AND MEN. (U. S. Dept. Agr. Yearbook of Agriculture 1938.) 1232 pp., illus.

U. S. GOVERNMENT PRINTING OFFICE: 1950

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington 25, D. C. - Price 10 cents

LIBRARY
CURRENT SERIAL RECORD
JUL 31 1950
U.S. DEPARTMENT OF